REPORT

PCB in the Kalamazoo River: Update for Decision Makers

Latest Findings for Sediment, Surface Water, and Fish

Allied Paper, Inc/Portage Creek/
Kalamazoo River Superfund Site
Kalamazoo and Allegan Counties, Michigan

August 31, 2001

BBL®
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Inside this Report...

☛ ***Not since 1993 and 1994 has the Kalamazoo River been such a busy place. Supplemental studies between 1999 and 2001 generated more than 2,000 new pieces of data on sediment, surface water, and fish. This new information, along with results expected from ongoing studies, will contribute to a better understanding of the Site and address questions remaining since completion of the initial Remedial Investigation field studies in 1994.***

The Otsego City Impoundment is just one area where conditions have improved over the past two decades.

What are the latest findings?

The most recent data and information on sediment, surface water, and fish gathered at the Site in 1999, 2000, and 2001 (all of which have already been submitted to MDEQ and USEPA) provide multiple lines of evidence to support the conclusions presented in the October 2000 draft Remedial Investigation Report and expanded in the Supplement to the RI/FS. Analyses of the latest data reveal:

- Natural attenuation is active in the Kalamazoo River and is responsible for observed reductions both in PCB bioavailability and associated potential risks;
- 2000-01 surface water data confirm transport of PCB continues to decline and verify the underlying mechanisms of natural attenuation;
- The 1993 and 2000 sediment sampling results allow for a comprehensive temporal comparison that confirms significant natural recovery of the river and validates the declines and half-times observed in other media;
- 1999 fish PCB data from MDEQ and KRSG confirm substantial reductions in PCB concentrations that support relaxing existing fish consumption advisories;
- New evaluations confirm the eroding river banks in the former impoundments are a significant ongoing source of PCB to the river; and
- Results of investigations by both MDEQ and USEPA of the ArvinMeritor, Inc. facility in Allegan verify the existence of other ongoing uncontrolled sources of PCB to the river.

What is planned for the future?

Additional findings are expected in the coming months as extensive ecological studies continue and the USEPA completes new sediment and soil sampling. In an ongoing effort to keep decision makers and others up to date on these and other studies, new findings will be made available. The draft RI/FS Reports and a variety of other information are available on the Kalamazoo River Study Group's project website at www.kzooriver.com.

TECHNICAL REPORT

PCB in the Kalamazoo River: Update for Decision Makers

Latest Findings for Sediment, Surface Water, and Fish

Allied Paper, Inc/Portage Creek/
Kalamazoo River Superfund Site
Kalamazoo and Allegan Counties, Michigan

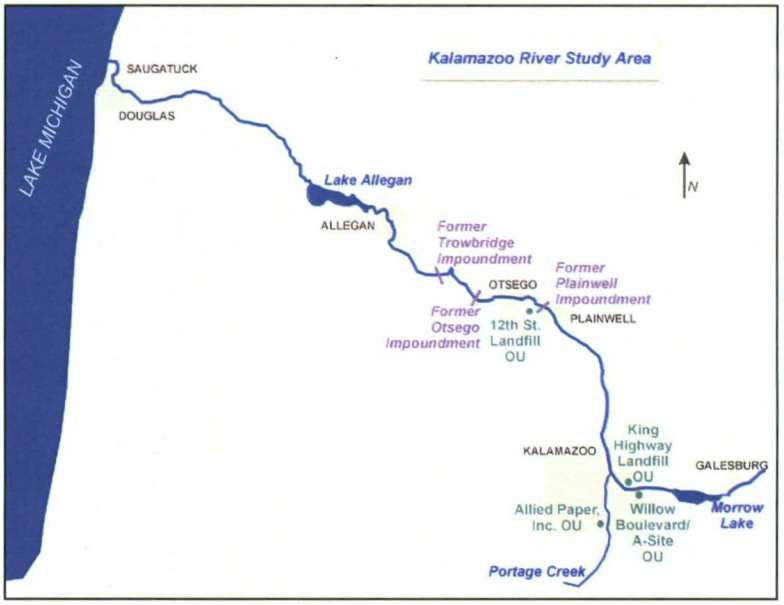
August 31, 2001

BBL®
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

PURPOSE AND BACKGROUND

Not since completion of initial remedial investigation field studies in 1994 has so much new data been generated about where PCB (polychlorinated biphenyls) are and how they move within the Kalamazoo River. With more than 2,000 new sediment, surface water, and fish data points now available from supplemental studies conducted between 1999 and 2001, analysts can determine how conditions have changed since 1994 and make comparisons to older historical data. The purpose of this report is to update decision makers and others on the latest results of these supplemental studies and what the findings mean for the future of the Kalamazoo River.

Much of the new data and associated findings were reported in the *Supplement to the RI/FS* report (Supplement; Blasland, Bouck & Lee, Inc. [BBL], 2000c) submitted by the Kalamazoo River Study Group (KRSG) to the Michigan Department of Environmental Quality (MDEQ) and U.S. Environmental Protection Agency (USEPA) in October 2000 as part of the remedial investigation and feasibility study (RI/FS; BBL, 2000a and 2000b) for the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site (Site). The RI/FS field work, initiated in 1993 and largely concluded in 1994, involved extensive sampling of Kalamazoo River sediments, surface water, floodplain soils, and biota (additional RI/FS work at four operable units along the river is progressing separately). The results of the 1993 and 1994 investigations were presented in a series of technical memoranda and addenda submitted to the MDEQ in the mid-1990s and summarized in the draft RI Report (BBL, 2000a) submitted in October 2000. Because questions about the Site remained following these efforts, the supplemental studies were designed and implemented to improve our understanding of where PCBs are in the Kalamazoo River and how they become available for exposure to people or wildlife. This Update report summarizes data and findings that were not available when the draft RI/FS and Supplement reports were submitted in October 2000.



VERIFICATION OF SITE CONCEPTUAL MODEL

The conceptual model for the Kalamazoo River is a set of ideas or, in scientific terms, hypotheses, drawn from information gathered during the RI about how the processes active in the river system affect the transport and bioavailability of PCB. The hypotheses have emerged from an extensive review of the RI data and more general information about transport and fate of PCB in aquatic ecosystems. The focus of the conceptual model is on the accumulation of PCB in fish, because assessments of human and ecological exposure revealed that consumption of fish from the river is the only pathway that leads to potentially unacceptable risks to humans and wildlife, and impacts remedial decision-making.

Since the October 2000 submittal of the draft RI/FS and Supplement reports, new fish, soil, sediment, and surface water data have been collected and analyzed. This new information further substantiates the prior conclusions about the distribution, transport, and fate of PCB within the Site and increases the confidence in the conceptual model presented in Section 7 of the draft RI Report (BBL, 2000a) and in Section 3.1 of the Supplement (BBL, 2000c). These data, submitted to MDEQ and USEPA in March 2000, provide indisputable evidence that the amount of PCB in the bed of the Kalamazoo River available for transport or biological uptake continues to decrease and that uncontrolled sources continue to add PCB to the river. The following subsections discuss new data in the context of the Site conceptual model and the state of understanding of the role PCB plays within the Kalamazoo River.

Decreasing Availability of PCB for Downstream Transport and Biological Uptake

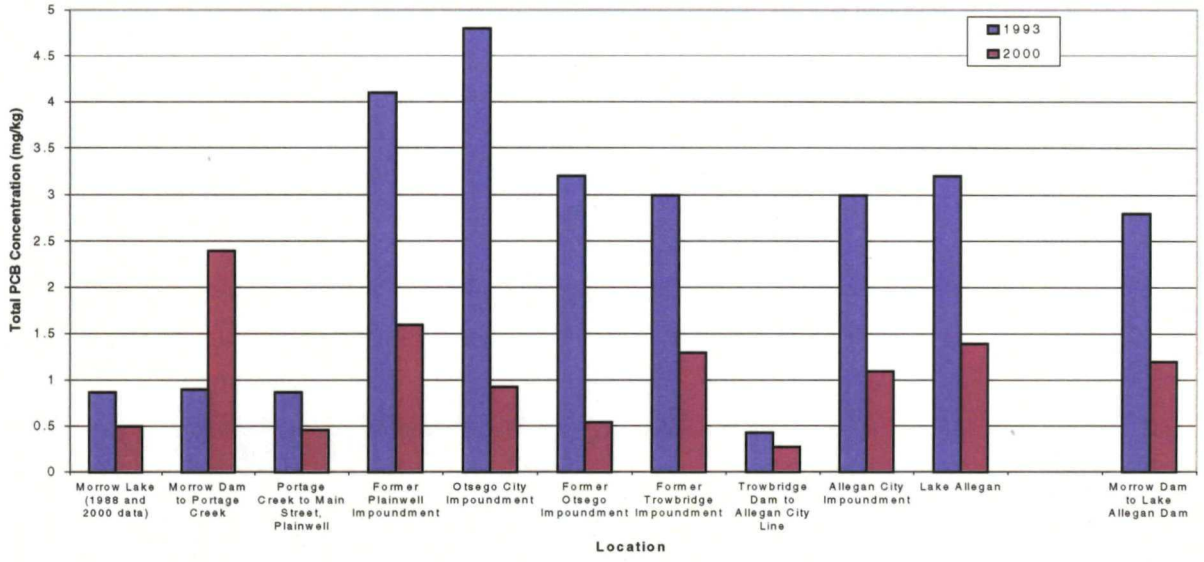
The significant downward trends in PCB levels in sediment, surface water, and fish (both spatially and temporally) discussed in the draft RI Report and the Supplement (BBL, 2000a; 2000c) are further supported by data collected in 1999, 2000, and 2001. Analyses show that despite the presence of continuing sources of PCB to the system, PCB levels in fish, sediment, and surface water have continued a steady decline since the mid-1980s. These trends indicate that ongoing natural attenuation processes are reducing the availability of PCB for downstream transport or biological exposure.

The most compelling evidence of natural attenuation observed in the sediment data is the decline of surface sediment PCB concentrations in the seven years between the 1993 and 2000 sampling events. Based on the PCB analysis of 369 sediment cores collected in 2000, decreases in surface sediment total PCB concentrations occurred river-wide, with the exception of the segment between Morrow Dam and

Portage Creek. This exception is attributable to a single high concentration sample collected in 2000 near the outfall of the Auto Ion Superfund Site. The differences between the 1993 and 2000 surface sediment PCB distributions are statistically significant for both the Lake Allegan and Portage Creek to Plainwell (Main Street) reaches ($p<0.05$, based on non-parametric statistics), which comprise 72% of the sediment surface area within the river.

To characterize the decrease in exposure to sediment PCB between the 1993 and 2000 sampling events, the surface area-weighted average concentration (SWAC) was examined. The SWACs for the individual reaches of the Kalamazoo River in 1993 and 2000 are presented in the figure below.

Comparison of SWAC in Surficial Sediment – 1993 vs. 2000



As the graph shows, the SWACs calculated using the 2000 data were lower than the corresponding 1993 values in all but one reach of the river (Morrow Dam to Portage Creek, due to the influence of one sample collected within 20 feet of the bank of the former Auto Ion facility; without which the SWAC decreases 60% to 0.36 (milligram per kilogram [mg/kg]). Taken together, the overall reduction in the SWAC for the whole river between Morrow Dam and Lake Allegan Dam was 56%, a decrease by over half in approximately 7 years.

To further evaluate the change in bioavailability of sediment PCB between the 1993 and 2000 distributions, total organic carbon (TOC)-adjusted PCB concentrations were analyzed. When the sediment data were adjusted for TOC content to provide a measure of bioavailable PCB, statistically

significant ($p<0.05$, based on non-parametric statistics) decreases in average TOC-adjusted PCB concentration were observed for the reach between Trowbridge Dam and the Allegan City Line, the Allegan City Impoundment, and Lake Allegan. Based on the comparison of the TOC-adjusted PCB concentrations measured in 1993 and 2000, bioavailable PCB has decreased significantly in reaches representing 83% of the river's surface area within the Site.

Average TOC-adjusted PCB SWACs were lower in 2000 than in 1993 throughout the river, with the exception of the former Plainwell Impoundment (see table below). Based on this analysis, the overall reduction in PCB bioavailability within the river between Morrow Dam and Lake Allegan Dam was 61%, which translates to a "half-time" (i.e., the time required for concentrations to be reduced by one-half) of less than 7 years.

TOC-Adjusted PCB SWAC in Surface Sediment

Reach	1993 mg PCB/kg TOC	2000 mg PCB/kg TOC	Percent Reduction
Morrow Lake (1,000 acres)	--	8.8	--
Morrow Dam to Portage Creek	44	23	48
Portage Creek to Main St. Plainwell	47	24	49
Former Plainwell Impoundment	64	120 (44)[1]	88 (31)[1]
Otsego City Impoundment	89	37	58
Former Otsego Impoundment	96	24	75
Former Trowbridge Impoundment	79	36	54
Trowbridge Dam to Allegan City Line	41	8.4	80
Allegan City Impoundment	72	16	78
Lake Allegan (1,600 acres)	69	25	64
Morrow Dam to Lake Allegan Dam	66	26	61

Note:
1. The increase in the former Plainwell Impoundment is caused by a single sample with anomalously low TOC; without that data point the TOC-adjusted PCB SWAC decreases 31% to 44 mg/kg.

In addition to significant decreases in the average surface sediment PCB and TOC-adjusted PCB concentrations, the range of PCB concentrations in surface sediment is narrowing as higher concentrations are detected less frequently. This is evident in the significant decrease of variance ($p<0.05$, using the F-test) in the surface PCB and TOC-adjusted PCB data in 2000 compared to the 1993 data in all reaches, with the exception of Portage Creek to Main Street, Plainwell.

The documented decrease of PCB concentration and bioavailable PCB in surface sediment that has occurred throughout the river since 1993 is the most important finding from these data. A reduction in bioavailable PCB and the general decline of PCB in surface sediment independently confirm both the

downward trends and the processes and rates of natural attenuation discussed in the draft RI and Supplement reports. Declines of surface sediment PCB will result in lower amounts of bioavailable PCB, lower PCB concentrations in fish, and reduced human and ecological exposure. The reduction in PCB observed in the results of 2000 sediment sampling is further supported by measured declines in fish and surface water as well as the depositional chronology of PCB determined through radio-dating of a number of finely-sectioned sediment cores. This additional supporting evidence is discussed in the following subsections.

Evidence from Geochronologic Core Data

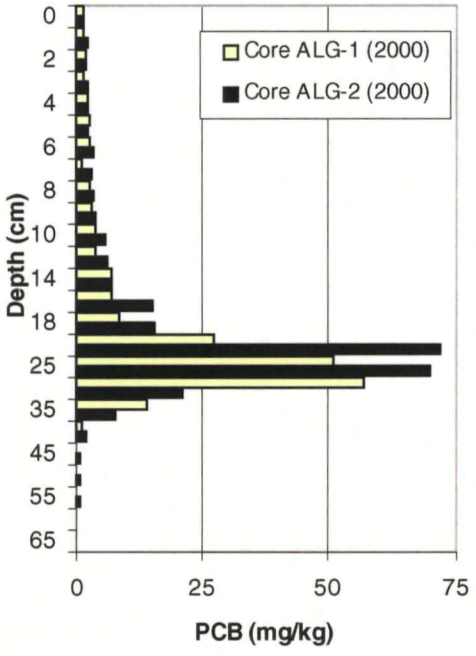
PCB concentrations in finely-sectioned sediment cores collected in 2000 corroborate the surface sediment PCB trends. The individual depth intervals of finely-sectioned cores analyzed for PCB were dated using radioisotopes to provide a chronology of PCB deposition. Isotope profiles in seven of these geochronologic cores collected in 2000 met necessary criteria (i.e., a readable profile indicative of steady historical deposition) for use in developing PCB deposition chronologies. Regression analyses in all cases show a statistically significant decrease of PCB in surface sediment occurring at similar rates between locations (including upstream in Morrow Lake). Estimated half-times from the geochronologic cores are similar to those calculated for other media (discussed later in this section) and are in line with the decreases in surface sediment PCB concentrations between 1993 and 2000. Estimated half-times since 1963 ranged from 5.7 to 9.7 years. To examine the potential effects of PCB loading reductions in the 1970s, regression analyses were performed again using only the data for sediments deposited after 1980. Estimated half-times since 1963 and 1980 are shown in the table below. The estimated half-times since 1980 ranged from 6.1 years for a core from the Allegan City Impoundment to 24 years for a core from Morrow Lake.

Sediment PCB Concentration Half-Times from Geochronologic Cores

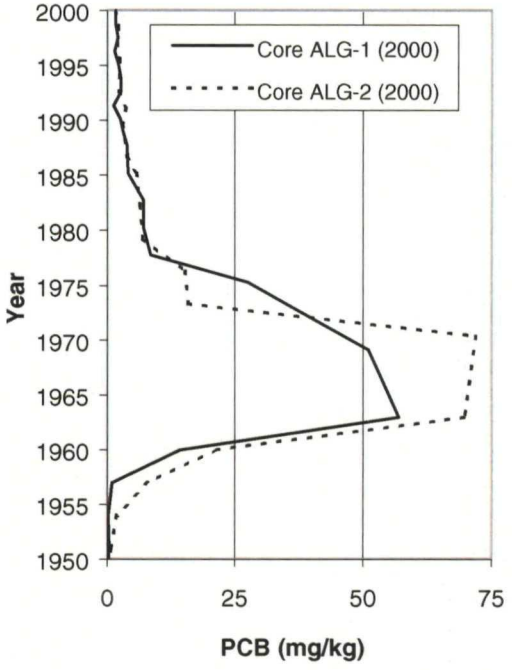
Impoundment	Core	Half-time (years)	
		Since 1963	Since 1980
Morrow Lake	MLG-1	6.4	7.0
	MLG-2	7.8	24
Trowbridge	TBG-2	6.8	6.3
Allegan City	ACG-1	5.7	6.1
Lake Allegan	ALG-1	6.3	8.9
	ALG-2	6.6	9.8
Kalamazoo Lake	KLG-1	9.7	7.8

Sample results from geochronologic cores collected from Lake Allegan (pictured below) clearly show that the highest PCB concentrations (dated from 1960 to the mid 1970s) are sequestered at depth and covered by 25 centimeters (cm) or more of cleaner sediment. This trend is predicted to continue as levels of bioavailable PCB available for downstream transport decline.

PCB in Lake Allegan Sediment



Chronology of PCB Deposition in Lake Allegan Sediment



Radioisotope data from the finely-sectioned cores provide a means to estimate the rates of key processes of sediment deposition and mixing that are fueling the attenuation of PCB in impoundments and the intrinsic recovery rate driven by those processes. Based on the sedimentation rates and surface mixing layer thickness, the estimated intrinsic half-times range from 2.1 years in Morrow Lake to 17 years in Kalamazoo Lake, and are well within the range of half-times derived from regression analysis. The new geochronologic cores confirm PCB-containing sediments are being covered by and mixed with cleaner, incoming solids in the impoundments. Taking steps to ensure that new or ongoing sources of PCB are controlled is clearly a key to continuing (or accelerating) recovery of the river.

Evidence from Surface Water Data

Surface water data collected in 2000 and 2001 confirm that, despite continued input from uncontrolled external sources, PCB transport in the Kalamazoo River is declining at a statistically significant rate. The surface water data collection included baseflow and high-flow sampling and produced more than 600 samples. Inclusion of the 2000/2001 data in the trend analyses presented in the draft RI and Supplement reports indicates that the trends predicted in those reports were accurate and are continuing; that is, new regression analyses show that PCB levels are declining statistically the same as they were between the mid-1980s and 1993/1994. Half-times of PCB concentration declines for samples collected at Plainwell and near Allegan City Dam during non-event or baseflow conditions were 5.8 and 6.0 years, respectively; these rates of decline are in the same range as those estimated for surface sediments.

PCB load, or the mass of PCB passing a given location per unit time, has declined substantially as well, particularly in the upstream reaches. Between Plainwell and the Allegan City Dam, PCB load continuously increases, then declines downstream of Lake Allegan Dam. Both surface water suspended solids and PCB data clearly show the effectiveness of Lake Allegan as a sediment "sink;" on an annual basis, more than 75% of the solids and 40% of the PCB that enter the lake are trapped. The depositional nature of Lake Allegan is of particular importance because it represents approximately two-thirds of the Site's surface area and contains approximately 70% of the Site's PCB mass in its sediment bed. Continuing deposition will cover more and more PCB, removing it from the surface sediment bioavailable zone and making it unavailable to fish and other biota.

Evidence from Fish Data

The reductions of surface sediment and surface water PCB concentrations are reflected in fish data collected from throughout the river. Fish data collected in 1999 by MDEQ as part of Michigan's Fish Contaminant Monitoring Program (FCMP) were made available after the submittal of the draft RI/FS and Supplement reports in October 2000 and included fillet samples from various locations, whole-body carp samples from Lake Allegan, and caged-fish samples from certain locations, such as Saugatuck, where similar data have been collected historically. The MDEQ data confirm the findings described in the draft RI Report and the Supplement. Moreover, a statistical analysis of the 1999 MDEQ data and the 1999 KRSG data (presented in the Supplement) indicates that the combination of these data into one comprehensive dataset for 1999 is appropriate.

Within the Site, statistically significant downward trends were observed in smallmouth bass and carp fillet data for samples collected from Morrow Lake, the former Plainwell Impoundment, and Lake Allegan. Downward trends calculated using the combined 1999 dataset are statistically more robust, but nonetheless the same as predicted using only data through 1997. Statistically significant trends were also observed in smallmouth bass and carp data from Battle Creek, in whole-body carp data from Lake Allegan, and in caged-fish data from Saugatuck. The decline of fish PCB levels was acknowledged by MDEQ in its FCMP document, where it was noted that "concentration declines [during whole-fish trend monitoring] were observed in fish from ... the Kalamazoo River" (MDEQ-SWQD, 2000, p.36).

Between 1993 and 1999, wet-weight PCB concentrations in fish have decreased upstream of the Site, within the MDNR-owned former impoundments, and in Lake Allegan (see table below). Wet-weight PCB concentrations in smallmouth bass (<16 inches) collected upstream of the Site fell 81% at Battle Creek and 48% at Morrow Lake. Within the former impoundments, reductions in wet-weight PCB measured in smallmouth bass ranged between 41% and 65%. Further, PCB concentrations in Lake Allegan smallmouth bass have declined 84% since the 1993 collection activities. Reductions in wet-weight PCB levels in carp (<22 inches) were within the same range (-52% to 64%) seen in the smallmouth bass fillet samples.

Arithmetic Mean PCB Concentration in Standardized (<16 inches[3]) Smallmouth Bass Fillets

Sampling Location	Wet-Weight PCB Concentration 1993[1](mg/kg)	1999[2](mg/kg)
Battle Creek	0.14	0.027
Morrow Lake	0.28	0.15
Mosel Avenue (Kalamazoo)	0.51	0.67
Former Plainwell Impoundment	1.8	0.62
Otsego City Impoundment	1.0	0.62
Former Otsego Impoundment	1.2	0.52
Former Trowbridge Impoundment	1.9	0.99
Lake Allegan	3.4	0.55

Notes:
1. 1993 smallmouth bass data collected by KRSG.
The number of samples per location ranged between 9 and 11 fillets.
2. 1999 smallmouth bass data are combined KRSG and MDEQ dataset.
The number of samples per location ranged between 7 and 21 fillets.
3. Consistent with the analysis methods in the Draft RI, size restrictions are used to provide a more consistent historical size class and reduce the potentially confounding effects of the positive correlation between fish size and PCB concentration.

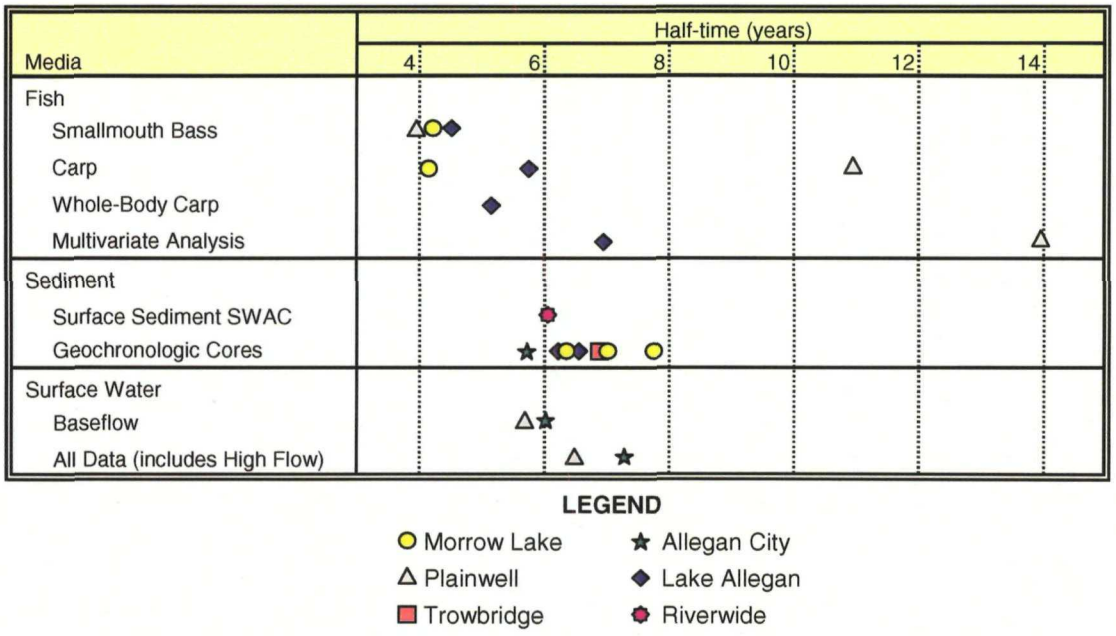
Sufficient historical and current fish PCB data are available for the Morrow Lake, former Plainwell Impoundment, and Lake Allegan sampling locations to estimate half-times from regression analyses of these data. Half-times estimated for smallmouth bass (<16 inches) collected from these locations are 4.3, 4.1, and 4.5 years, respectively. PCB levels in carp (<22 inches) also are falling, but not as rapidly, with half-times estimated for Morrow Lake, Plainwell, and Lake Allegan of 4.2, 11, and 5.9 years, respectively. These half-times are consistent with those observed in sediment and surface water in the same areas.

Multivariate statistical analyses were conducted to consider PCB levels in all new fish data for the former Plainwell Impoundment and Lake Allegan. Multivariate statistical analyses allow for the use of a greater amount of information (e.g., includes fish of all lengths) than the bivariate analyses described previously. The former Plainwell Impoundment and Lake Allegan sampling locations were analyzed because they had the largest amount of fish monitoring data. Multivariate analyses show significant decreases in PCB concentration over time at both locations: half-times of 14 years and 7.0 years in the former Plainwell Impoundment and Lake Allegan, respectively.

Based on the analyses of the 1999 KRSG and 1999 MDEQ fish data, it is apparent that some of the current fish consumption advisories are more stringent than necessary and could be relaxed or eliminated. The allowable changes in fish consumption advisories are significant in terms of remedial goals for the river. Both smallmouth bass and carp are now edible in some amount by the general population, in contrast to the Michigan Department of Community Health's (MDCH's) existing "do not eat" advisories, most of which have not been changed in several years despite collection of new data. The achievement of less restrictive advisories is one of MDEQ's own remediation goals for the river, and the data clearly indicate that there is an immediate opportunity to reach that goal. For example, only 2 of the 120 smallmouth bass fillets collected in 1999 between Morrow Dam and Lake Allegan Dam had PCB concentrations greater than the 2 parts per million (ppm) Food and Drug Administration (FDA) tolerance level used to set consumption advisories for the general population.

With remarkable consistency, as demonstrated by the overlap in estimated half-times (see summary figure below), the sediment, surface water, and fish data developed by both the MDEQ and the KRSG provide multiple lines of evidence documenting the rates and processes associated with the recovery of the Kalamazoo River. These natural processes are significantly decreasing PCB bioavailability over time and are thereby reducing PCB exposure for both humans and wildlife that consume Kalamazoo River fish.

Summary of Media-Specific Half-times
Based on Data Through 1999-2001 Sampling



Exposed Sediments and Other External Sources of PCB to the Kalamazoo River

The evaluations of potential remedial alternatives for the Site must take into consideration the impact that current, continuing external sources of PCB have on the Kalamazoo River relative to the benefit of the remedial action proposed in the draft FS report (BBL, 2000b) (i.e., bank stabilization at the former impoundments, monitored natural attenuation, and institutional controls). As the observed trends of decreasing PCB concentrations in surface water, sediment, and fish continue over time, these continuing external sources of PCB will become increasingly important factors which will affect, and ultimately control, PCB levels in environmental media in the absence of mitigation. By far the most significant of these sources are the exposed sediment banks of the three Michigan Department of Natural Resources (MDNR)-owned former impoundments, which have been determined to provide a substantial load of PCB to the river. On a smaller scale, but by identical mechanisms, sediments that were exposed after the

2- to 3-foot drawdown of water in the Otsego City Impoundment in 1991 also provide a continuing source of PCB to the Kalamazoo River. Remedial alternatives that address these primary sources of PCB to the river will at the same time enhance the rate of natural attenuation in environmental media and further accelerate the already declining availability of PCB for further transport or exposure. The following two subsections further discuss the role of the exposed sediment banks and other external sources.

Exposed Sediment Banks in the MDNR-Owned Former Impoundments

It is well established in the draft RI/FS and Supplement reports that the banks in the three MDNR-owned former impoundments are a significant ongoing source of PCB to the river. Since submittal of those document in October 2000, several new pieces of information have emerged which directly support that conclusion. One of the best ways to estimate the rates of erosion from the former impoundment banks is through direct measurement. An ongoing survey of the banks of the Kalamazoo River is underway to monitor the rates of soil loss at various locations within the former impoundments. The first survey of these locations was conducted in March 2001, shortly after a 10-year flood event, and therefore did not yield data from which typical annual erosion rates could be calculated (results were submitted to the MDEQ in July 2001 [BBL, 2001]). However, as noted in both previous and recent efforts, changes in profiles of the banks of the MDNR-owned former impoundments show that the exposed sediment is slumping into the river, where it then provides a constant source of PCB as clumps slowly disintegrate and wash away. These ongoing alterations to the banks have been directly observed on a localized scale in the field, and assessed on a broad scale with the review of recent and historical aerial photographs.

Computer analysis of recent and historical aerial photographs indicate that eroding sediments in the former impoundments have contributed an overall average of 21 kg per year of PCB since the water levels were drawn down in the 1970s. Previous bank erosion estimates based on surveys in 1999 of transects originally established in 1993/1994 resulted in an estimated PCB loading rate of approximately 30 kg per year from the three MDNR-owned former impoundments (BBL, 2000c). As additional direct measurements of bank loss are obtained over time, loading rates from the former impoundments will be reassessed. The real impact of PCB concentrations from the erosion of the exposed sediments of the MDNR-owned former impoundments cannot be ignored. For example, in an area where losses were observed in the former Otsego Impoundment, depth-weighted surface PCB concentrations measured in the upper 2.5 feet of three cores of exposed sediment collected in 1993/1994 averaged 12 mg/kg, 14 mg/kg, and 51 mg/kg, respectively. These concentrations are representative of sediment being slowly eroded and transported downstream.

The significance of PCB loading from the banks of the former impoundments is suggested by the distribution of PCB in Site media. Similar to data reported in the draft RI Report and the Supplement (BBL, 2000a; 2000c), the 1999-2001 data indicate that PCB concentrations in sediment, surface water, and fish all increase markedly within the former impoundments relative to other reaches. PCB uptake, which was directly measured by MDEQ's 1999 caged-fish sampling, showed a 3-to 5-fold increase for caged fish sampled downstream of Plainwell when compared to fish sampled at the mouth of Portage Creek. A similar pattern is observed in surface water samples collected in the vicinity of the former impoundments, where the river reaches between M-89 in Plainwell and 26th Street at the Trowbridge Dam contributed over 55% of the total annual PCB mass to the system. These increases in PCB load are accompanied by increases in the water column PCB to total suspended solids (TSS) ratio throughout several measurement points during 2000/01 high-flow events. Similarly, the TOC-adjusted PCB concentrations increase at the former Plainwell Impoundment, and are sustained thereafter downstream at elevated levels through the former Trowbridge Impoundment. Downstream of the former Trowbridge Impoundment, the TOC-adjusted PCB levels in surface sediment drop to concentrations similar to those observed upstream of the former impoundments. MDNR-owned former impoundments have had a significant historical impact and continue to affect PCB distribution in the river by providing an ongoing external source of PCB to the Kalamazoo River. This source of PCB is expected to continue affecting environmental media unless mitigated.

Other External Sources

Data collected for the RI and supplemental studies, as well as continuing efforts by the MDEQ, have provided incontrovertible evidence that other external sources of PCB to the Kalamazoo River exist both upstream of and within the Site. The presence of these other ongoing sources is confirmed in the 1999-2001 PCB analytical data for surface water, sediment, and fish, as well as other media. These sources must be factored into the evaluation of response actions at the Site, especially in considering the degree to which they may inhibit recovery of the river, despite improvements realized by any remedy within the Site itself.

Upstream Sources

It is well documented that Morrow Lake, located immediately upstream of the Site and formed by impoundment of the Kalamazoo River, is a continuing source of PCB to the Site. New data, collected since the submittal of the draft RI/FS and Supplement reports, add to this body of evidence.

PCB sources to Morrow Lake are not well identified, and it is currently unknown to what extent these sources continue to load PCB either directly to the lake or to the Kalamazoo River upstream of the lake. The MDEQ has recognized the impact these upstream sources are having on upstream reaches of the river system. Specifically, the MDEQ recently (2001) recommended a fish consumption advisory for sensitive populations for the Ceresco Impoundment, located approximately 25 miles upstream of Morrow Lake, due to unacceptably high concentrations of PCB in carp fillet samples collected in 1999 (MDCH, 2001). In addition, the MDEQ recommended to the MDCH (in the 2000 FCMP) that an advisory be instituted for sensitive populations, recommending no more than one meal per week of smallmouth bass from the Kalamazoo River between Battle Creek and Morrow Dam, based on the results of 1999 sampling showing "elevated concentrations of PCBs" (MDEQ-SWQD, 2000). Overall, the results of the MDEQ's 1999 fish sampling showed that PCB were detected in 91% (20 of 22 fillet samples) of smallmouth bass and 100% (22 of 22) of carp fillet samples collected from the Ceresco Impoundment and Morrow Lake.

These external sources of PCB to the Site have the potential to impede the ongoing decreases in PCB bioavailability observed within the Site. As evident by the 2001 MDCH fish consumption advisory, uncontrolled upstream sources of PCB have sustained PCB concentrations in fish above background levels. Moreover, with the addition of a consumption advisory at Ceresco, it is apparent that the presence and contribution of these upstream sources of PCB cannot be ignored. As discussed earlier, the results of the 1999 fish sampling indicate that natural attenuation has reduced fish PCB levels to concentrations that would warrant the relaxation of certain fish consumption advisories currently in place within the Site. However, without additional source control to alleviate the burden imposed on the Site by uncontrolled sources of PCB both within and upstream of the Site, the ultimate goal of removal of consumption advisories throughout the river will not be realized.

The large mass of PCB in Morrow Lake sediment is a large and significant potential source of PCB to the Site. Data collected in 2000 allow for a more accurate assessment of the total PCB mass in Morrow Lake sediments, which is estimated to be approximately 1,900 kg. This PCB mass represents about one-fifth of the total PCB mass in sediment between Morrow Dam and Lake Allegan Dam. The average surficial (0- to 2-inch) sediment PCB concentration in Morrow Lake is approximately 0.5 mg/kg, and the average total PCB concentration just beneath the surface (2 to 6 inches) is 0.35 mg/kg; these concentrations are comparable to those measured in reaches within the Site proper.

The PCB in and upstream of Morrow Lake have a quantifiable impact to the Site, most easily measured as the PCB load introduced via the flow of surface water, either in dissolved phase or attached to suspended particles. Surface water samples collected by the KRSG in 2000-2001 from River Street, the sampling location just below Morrow Lake, contained PCB concentrations ranging from not detected to 0.0049 micrograms per liter (µg/L). Note that the quantitation limit (i.e., that concentration above which PCB levels can reliably be reported) for PCB in surface water is much higher than the MDEQ surface water quality criterion, so if any amount of PCB is detected in a sample, it exceeds the surface water quality criterion by at least two orders of magnitude. It is estimated that approximately 2.7 kg of PCB are transported from upstream sources into the Site on an annual basis. This represents approximately 13% of the annual PCB load estimated to pass over Lake Allegan Dam at the downstream end of the Site.

Non-Paper Industry Sources

Historically, different PCB products (e.g., Aroclors) were used by industries for various applications, including hydraulic fluids, cutting oils, heat transfer fluids, wax casting, and carbonless copy paper (Durfee et al., 1976). PCB were widely used to insulate and transfer heat in electrical systems, and were also used in the manufacture of carbonless copy paper from 1957 through 1971. PCB apparently originating from and still resembling Aroclor 1242 dominates the PCB composition of paper-making residuals studied at the four non-river operable units (OUs) within the Site. Higher-chlorinated PCB Aroclors (e.g., Aroclors 1254 and 1260), which were commonly used in electrical equipment and other applications, typically are not found or are evident only in very low concentrations in residuals at these OUs.

The presence of PCB attributable to non-paper industries is evident in data collected from the Kalamazoo River since the start of the RI. The clearest illustrations of this non-paper industry contribution are the types of PCB found in Morrow Lake sediment and the PCB-related fish consumption advisories for Morrow Lake. Morrow Lake is isolated from any potential influence from the KRSG facilities because it is upstream of the Site. Review of the fish and sediment data, including chromatograms for Morrow Lake, indicates Aroclor 1254 and, to a lesser extent, Aroclor 1248 are responsible for much of the PCB composition observed in these media. Aroclor 1254-type PCB are currently present in the surface sediment throughout the river.

Additional evidence presented in the draft RI Report (BBL, 2000a) verifies that PCB from other non-paper industrial sources along the river have been released to the Site by direct discharge (e.g.,

wastewater effluent), indirect discharge through publicly owned treatment works, and non-point source runoff from upland areas. The 2000 data bolster these findings. As an example, a surficial sediment sample collected from a deposit near the Auto Ion facility in the city of Kalamazoo contained PCB predominantly characterized as Aroclor 1254 at a total concentration of 51 mg/kg. That PCB cannot be attributed to paper manufacturing or paper recycling processes.

In November 2000, the MDEQ conducted an investigation of one of the facilities identified in the draft RI Report (BBL, 2000a) as a highly likely source of PCB to the river. The MDEQ's study confirmed the existence of uncontrolled sources of PCB to the Kalamazoo River in the area of the ArvinMeritor, Inc. (formerly Rockwell International) facility in Allegan, Michigan. The investigation included the sampling and analysis of soil, groundwater, and a layer of oil observed to be floating above the shallow water table (0.5 to 7.5 feet below land surface) underneath a residential area between the southern property line of the ArvinMeritor facility and the Kalamazoo River. Soil samples collected from a river bank within the immediate vicinity of the ArvinMeritor outfall pipeline to the Kalamazoo River contained PCB concentrations as high as 200 mg/kg at a location approximately 60 feet from the river. The oil observed to be floating on top of the water table contained PCB concentrations up to 260 mg/L, and groundwater also contained detectable PCB concentrations. The detections of PCB were quantified as Aroclor 1254 or a combination of Aroclors 1248 and 1254 (Earth Tech, Inc., 2000).

In August 2001, the USEPA issued an Administrative Order pursuant to Section 106(a) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA), regarding the ArvinMeritor Site. In the Order, USEPA outlines removal actions that must be conducted "to abate an imminent and substantial endangerment to the public health, welfare, or the environment" from PCB. USEPA investigators found PCB in the surface water, groundwater, and surface soils at the facility. The contaminated soils were found to be eroding into the Kalamazoo River, and "two plumes of oil contaminated with PCBs have been discovered leaving the site...and entering the Kalamazoo River." Analytical results revealed PCB concentrations as high as 150 ppm (USEPA, 2001).

CONCLUSIONS

The data from the supplemental studies completed to date support the two primary conclusions developed in the draft RI Report (BBL, 2000a) and the Supplement (BBL, 2000c); namely that:

- PCB concentrations in Kalamazoo River fish, surface water, and surface sediment have been decreasing over the past 20 years as a result of natural attenuation. These declines are expected to continue to improve conditions into the future; and
- Ongoing, uncontrolled sources of PCB to the river remain, depressing the rate of natural attenuation.

REFERENCES

Blasland, Bouck & Lee, Inc. (BBL). 2000a. *Draft Phase I Remedial Investigation Report - Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site* (Syracuse, NY: October 2000).

BBL. 2000b. *Draft Phase I Feasibility Study Report - Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site* (Syracuse, NY: October 2000).

BBL. 2000c. *Supplement to the Phase I RI/FS Report - Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site* (Syracuse, NY: October 2000).

BBL. 2001. *Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site - Technical Memorandum - Results of the March 2001 Survey of Erosion Pins* (Syracuse, NY: July, 2001).

Durfee, R.L., G. Contos, F.C. Whitmore, J.D. Barden, E.E. Hackman, and R.A. Westin. 1976. *PCBs in the United States Industrial Use and Environmental Distribution* (Springfield, VA: February 1976).

Earth Tech, Inc. 2000. *Technical Memorandum for the PCB Sampling Event at the 267 North Street Residential Site, Allegan, Michigan* (Grand Rapids, MI: December 2000).

Michigan Department of Community Health (MDCH). 2001. *Michigan 2001 Fish Advisory* (Lansing, MI: March, 2001).

Michigan Department of Environmental Quality - Surface Water Quality Division (MDEQ-SWQD). 2000. *Michigan Fish Contaminant Monitoring Program.* 2000 Annual Report. Lansing, MI.

USEPA. 2001. *Administrative Order Pursuant to Section 106(a) of CERCLA, Docket No. V-W-01-C-654, In the Matter of: Rockwell International Site Allegan, Michigan.* USEPA, Region 5: August, 2001.